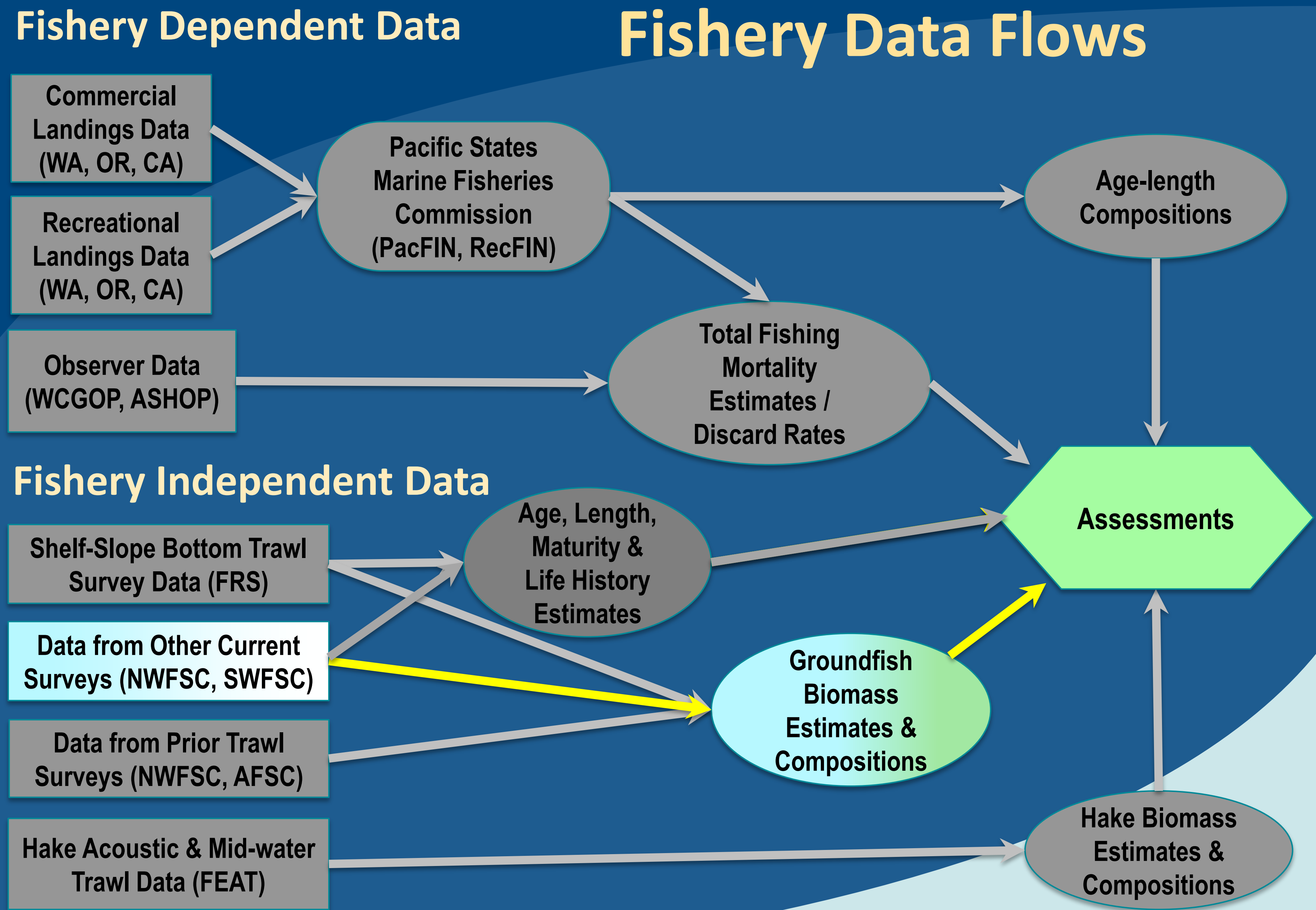
Rockfish recruitment and ecosystem assessment survey

Fishery Data Flows

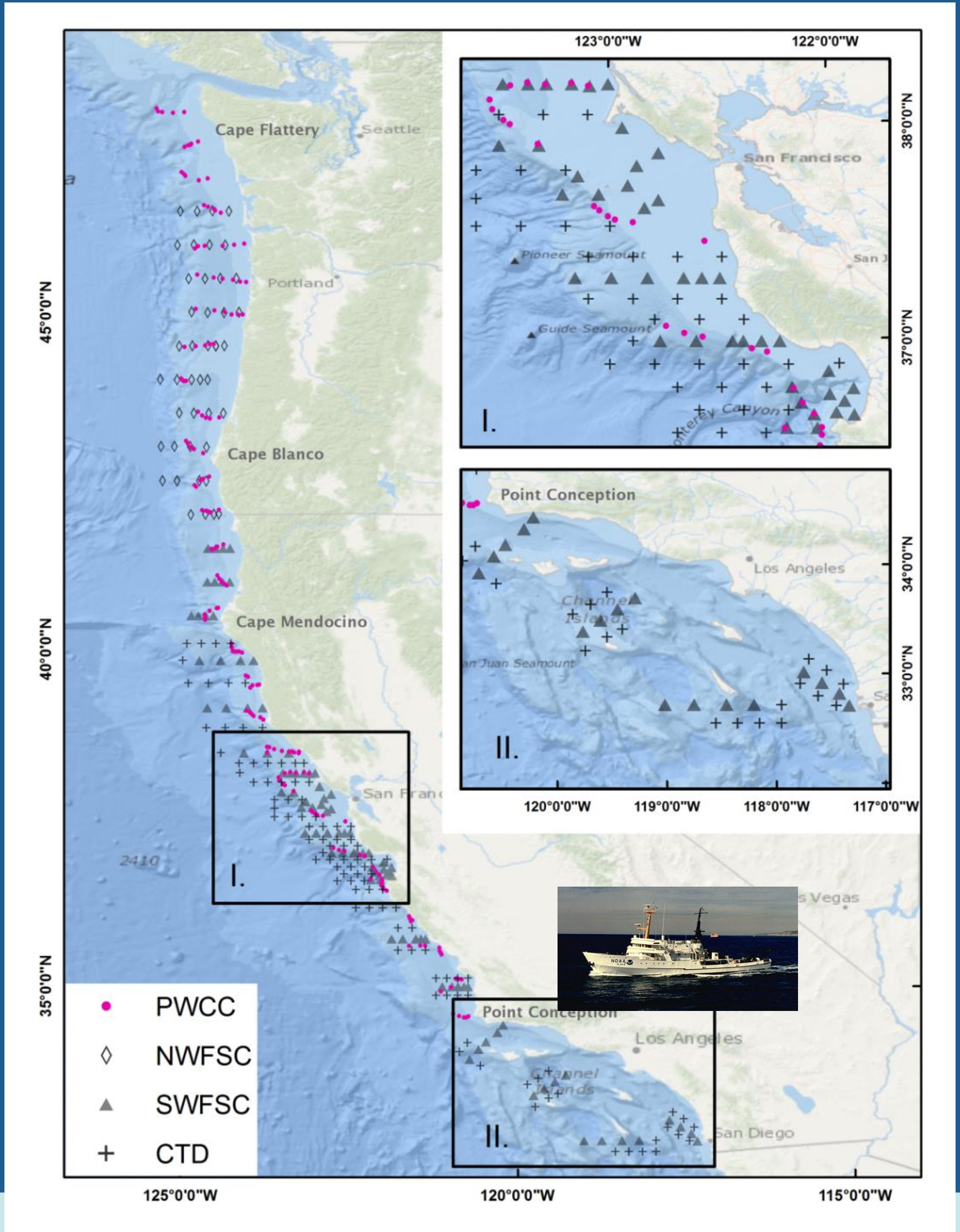


Survey Objectives

- Develop estimates of abundance for pelagic Young-of-the-year rockfish (*Sebastes* spp.) and other groundfish for use as pre-recruit indices in stock assessments (Assessment survey)
- Improve our understand of the physical and biological ecosystem factors that lead to strong or weak year classes (Process studies)
- To improve our understanding of the spatial and temporal variability in the micronekton (forage) assemblage, including the role of YOY rockfish and other groundfish within that assemblage, particularly as related to climate variability and oceanographic conditions (Ecosystem studies)

Area Surveyed

- The SWFSC juvenile survey has sampled a "core" area of Central California since 1983 (21 to 30 DAS), expanded range in 2004 from the U.S./Mexico border to Cape Mendocino (~45 DAS).
- A PWCC/NWFSC survey was initiated in 2001, surveyed the Pacific Northwest through Monterey Bay (single sweep south) through 2011 (~ 21 days).
- The SWC and NWC conducted a joint survey in 2013, with the goal of covering the entire coast (60 DAS)



From 1983 through 2008 all cruises were on the R/V David Starr Jordan, since then a new ship every year (vessel effects!)

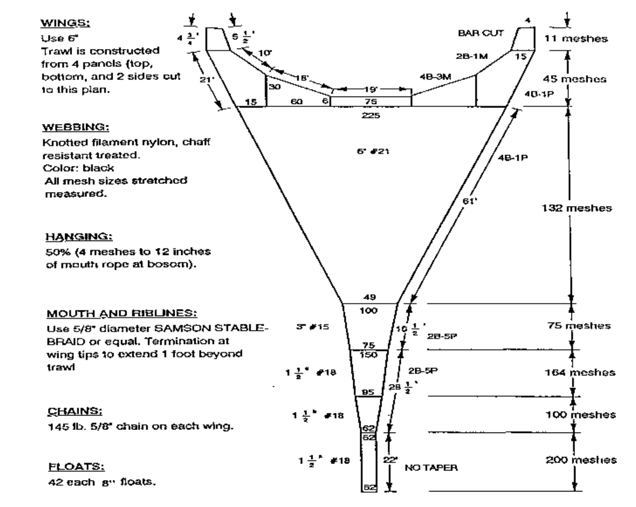


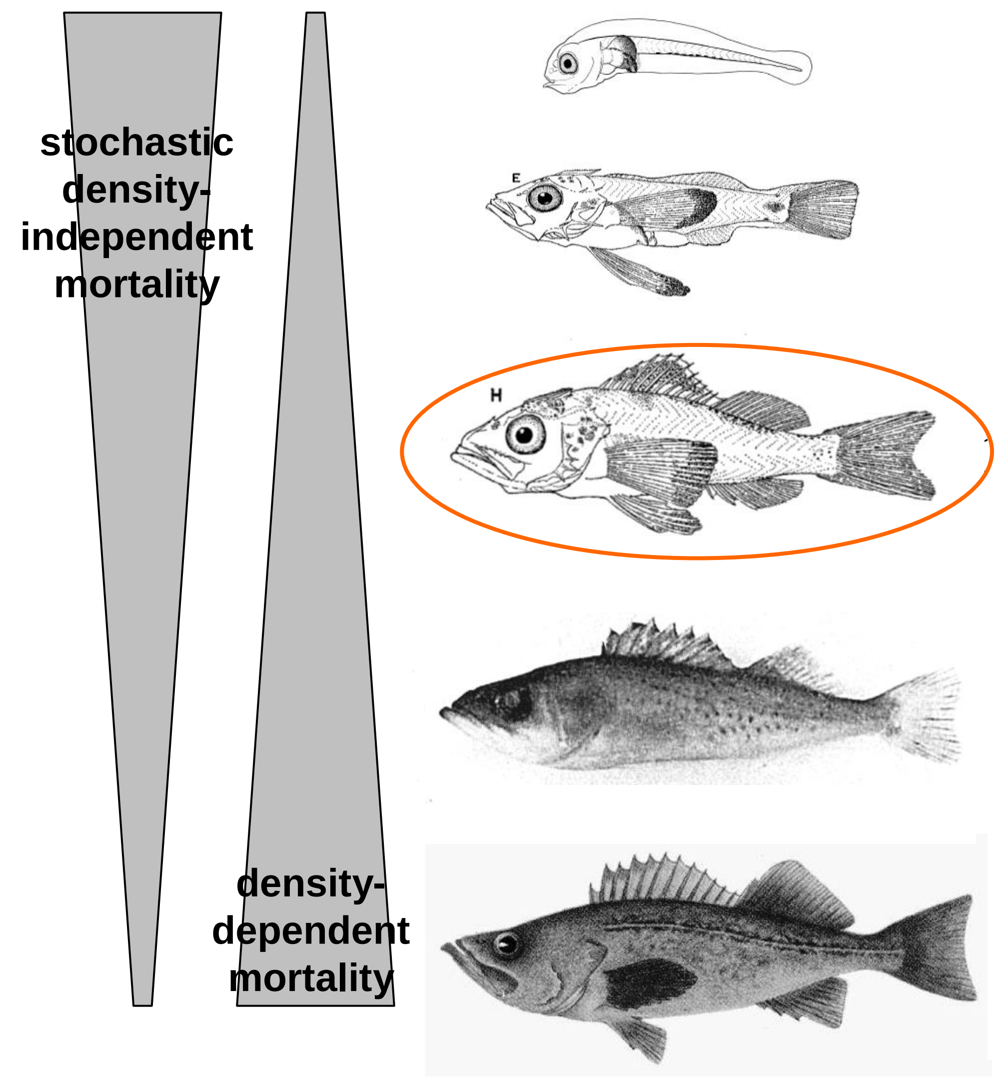
Diagram of mid-water trawl specifications.

Midwater trawling conducted at night, typically 30 m HR depth, using a modified Cobb trawl with 3/8” codend liner

Rockfish and other species are sorted, measured and enumerated at sea

NOAA FISHERIES

Primary target is pelagic juvenile (age 0) rockfish, to use as recruitment indices in stock assessments

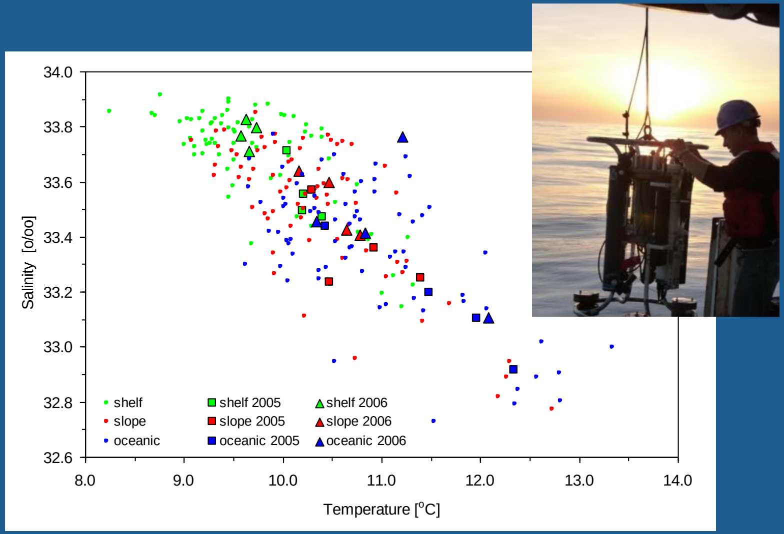


Larval abundance used as index of spawning biomass (cowcod, bocaccio, others)

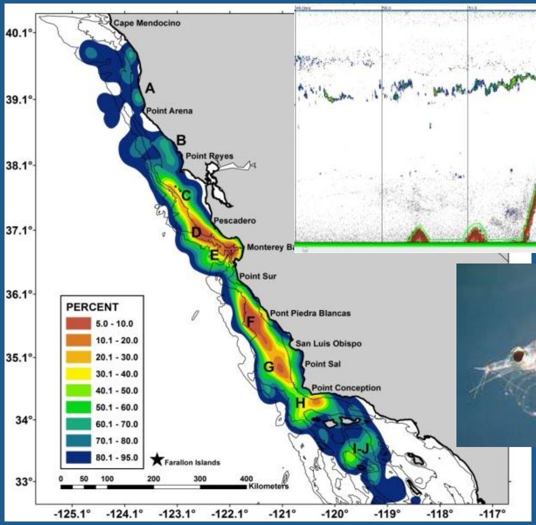
Pelagic YOY used as an Age 0 (recruitment) index (standardize to 100 days)

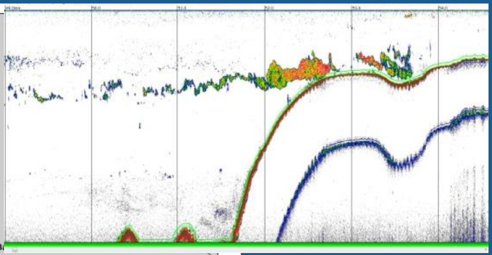
Fisheries and survey data used to inform abundance trends, population structure

In addition to quantifying juvenile rockfish and other micronekton, research plan includes a suite of physical and biological observations

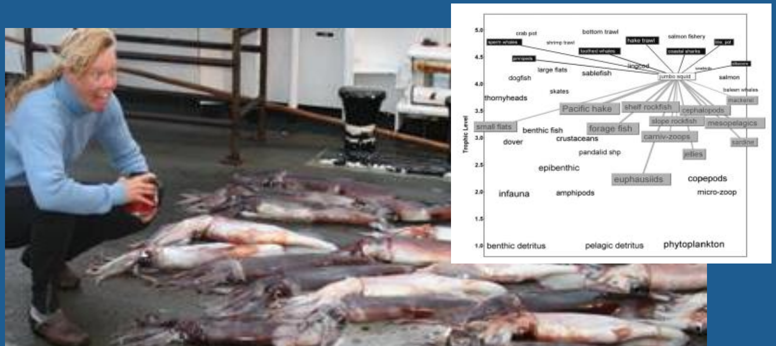


Physical Oceanography (CTD and Fluorometry), upwards of 300 casts per year, data online

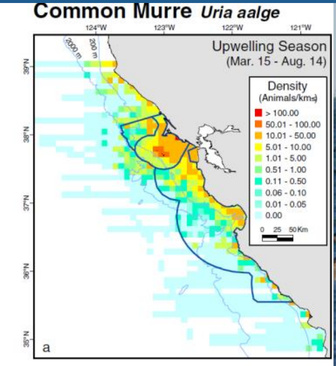





Acoustic estimates of abundance and distribution of krill and other micronekton



Sampling on adult rockfish and jumbo squid for life history and food habit studies



Seabird and marine mammal transects during daylight hours (data back to 1987)

NOAA FISHERIES

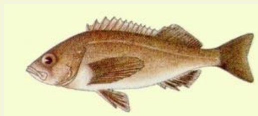
Survey Objectives

- Develop estimates of abundance for pelagic Young-of-the-ear rockfish (*Sebastes* spp.) and other groundfish for use as pre-recruit indices in stock assessments (Assessment survey)
- Improve our understand of the physical and biological ecosystem factors that lead to strong or weak year classes (Process studies)
- To improve our understanding of the spatial and temporal variability in the micronekton (forage) assemblage, including the role of YOY rockfish and other groundfish within that assemblage, particularly as related to climate variability and oceanographic conditions (Ecosystem studies)

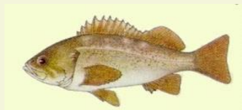




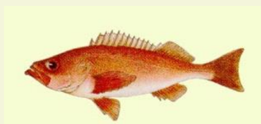
The cast of characters



widow rockfish
Sebastes entomelas
60 yr, 59 cm max
schooling
commercial

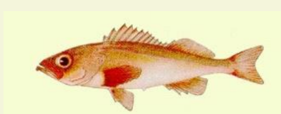


yellowtail rockfish
Sebastes flavidus
64 yr, 66 cm max
schooling
commercial



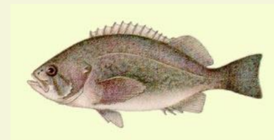
chilipepper
Sebastes goodei
35 yr, 59 cm max
schooling
commecial

squarespot rockfish
Sebastes hopkinsi
29 yr, 29 cm max
aggregate around outcrops
commercial bycatch

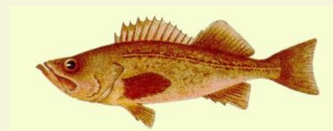


shortbelly rockfish
Sebastes jordani
32 yr, 35 cm max
schooling
unexploited

brown rockfish
Sebastes auriculatus
35 yr, 56 cm max
nearshore, soft bottom
sport & commercial



blue rockfish
Sebastes mystinus
44 yr, 53 cm max
Schooling, nearshore
sport



bocaccio
Sebastes paucispinis
45 yr, 91 cm max
schooling (various),
commercial, depleted

canary rockfish
Sebastes pinniger
84 yr, 76 cm max
aggregate around outcrops
commercial, depleted

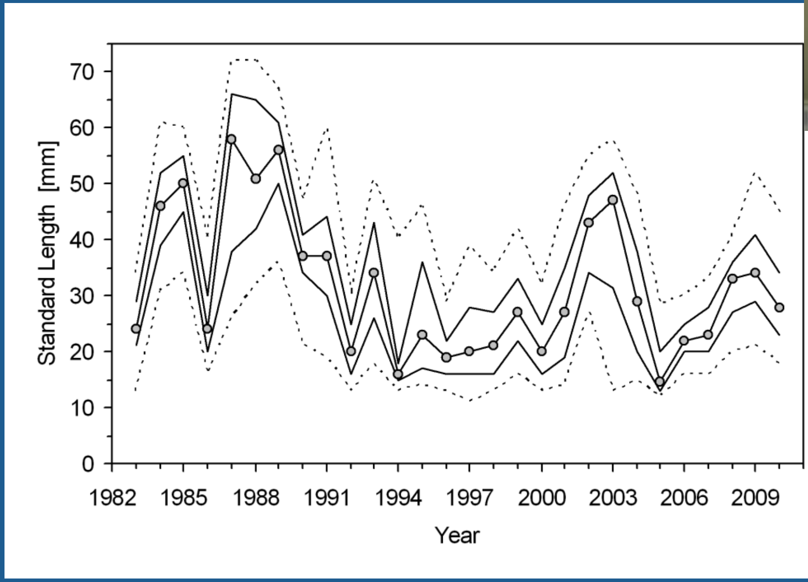
stripetail rockfish
Sebastes saxicola
38 yr, 41 cm max
solitary around mud
commercial bycatch

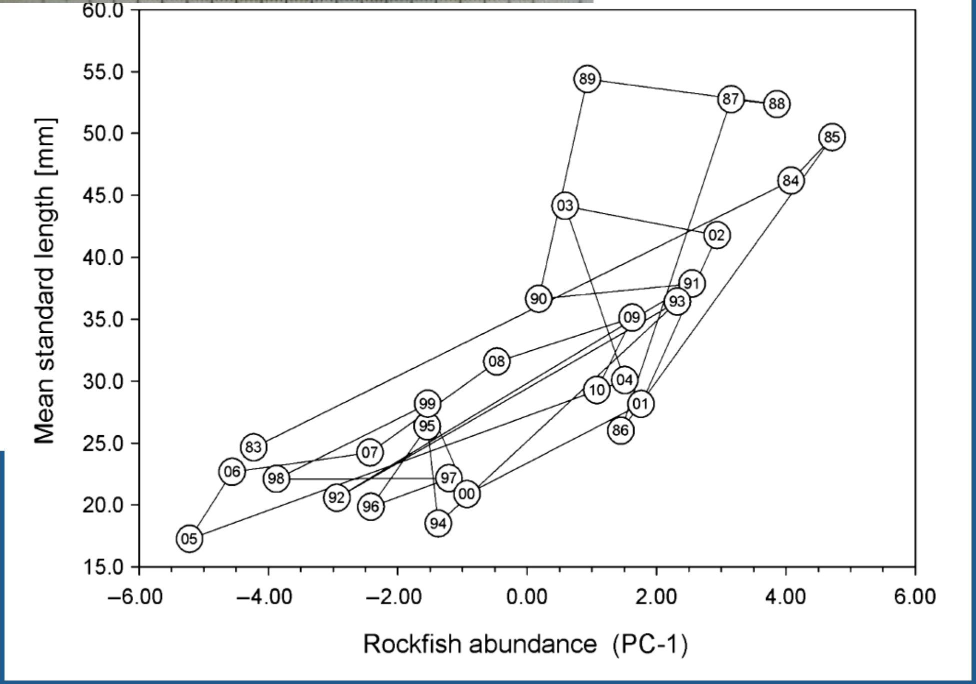
Illustrations from Eschmeyer *et al.* 1983, other information from Love *et al.* 2002





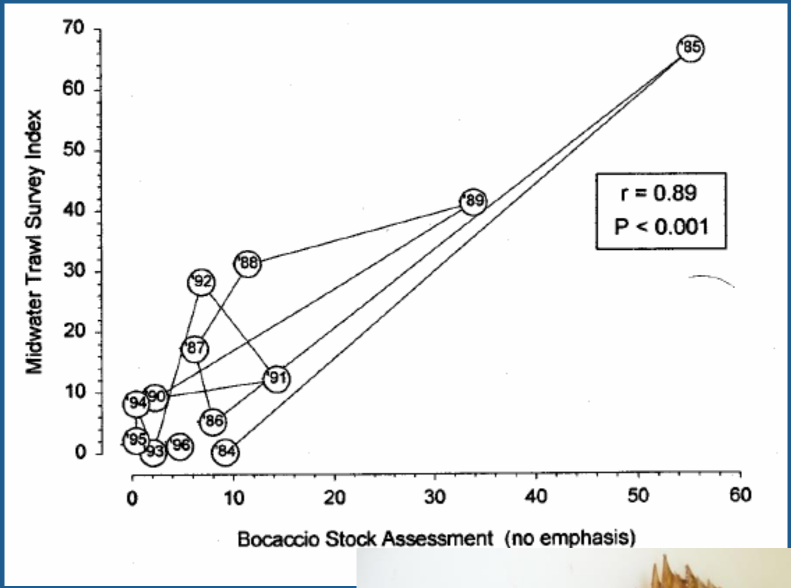
Ten winter-spawning species make up >95% of total juvenile rockfish catch, these ten have sufficient data for relative abundance indices (most others do not). These species represent about 75-80% historical CA landings rockfish.





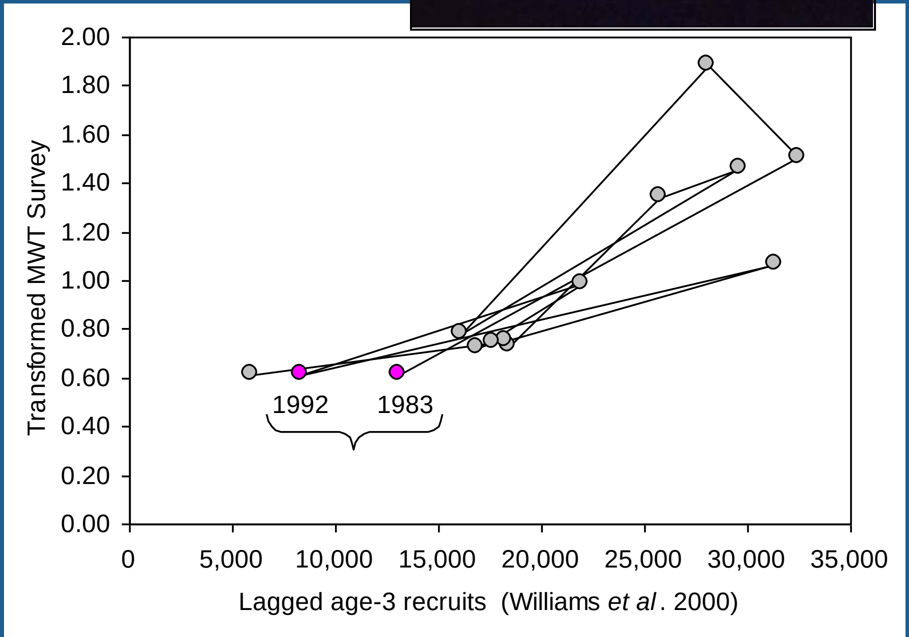
n' = exp[-0.04(100-age')]

Fish are adjusted to a common age (100 days). Years of high abundance are associated with larger sizes, inferring higher survival of fish released early in the spawning season



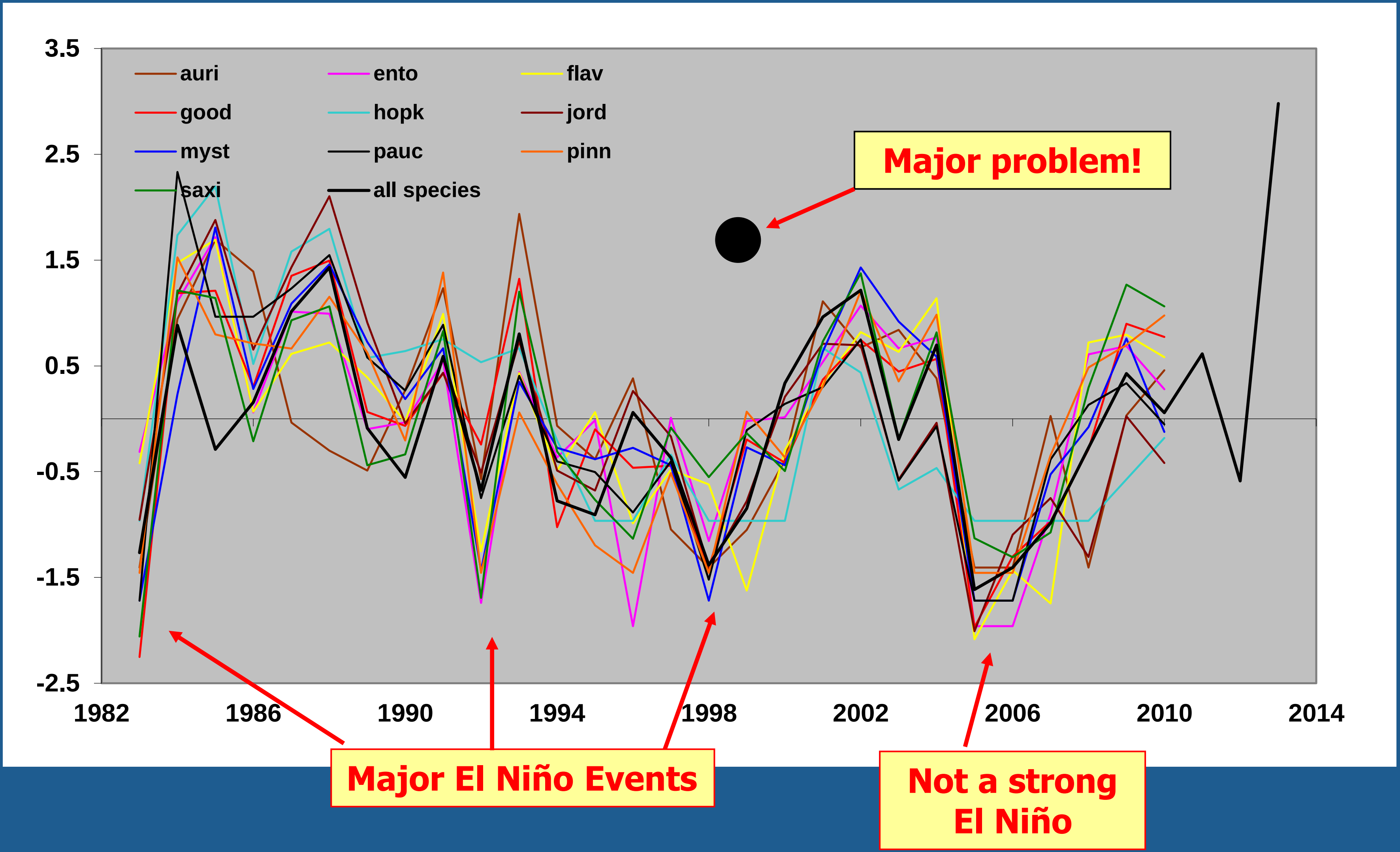
Widow rockfish

Bocaccio rockfish

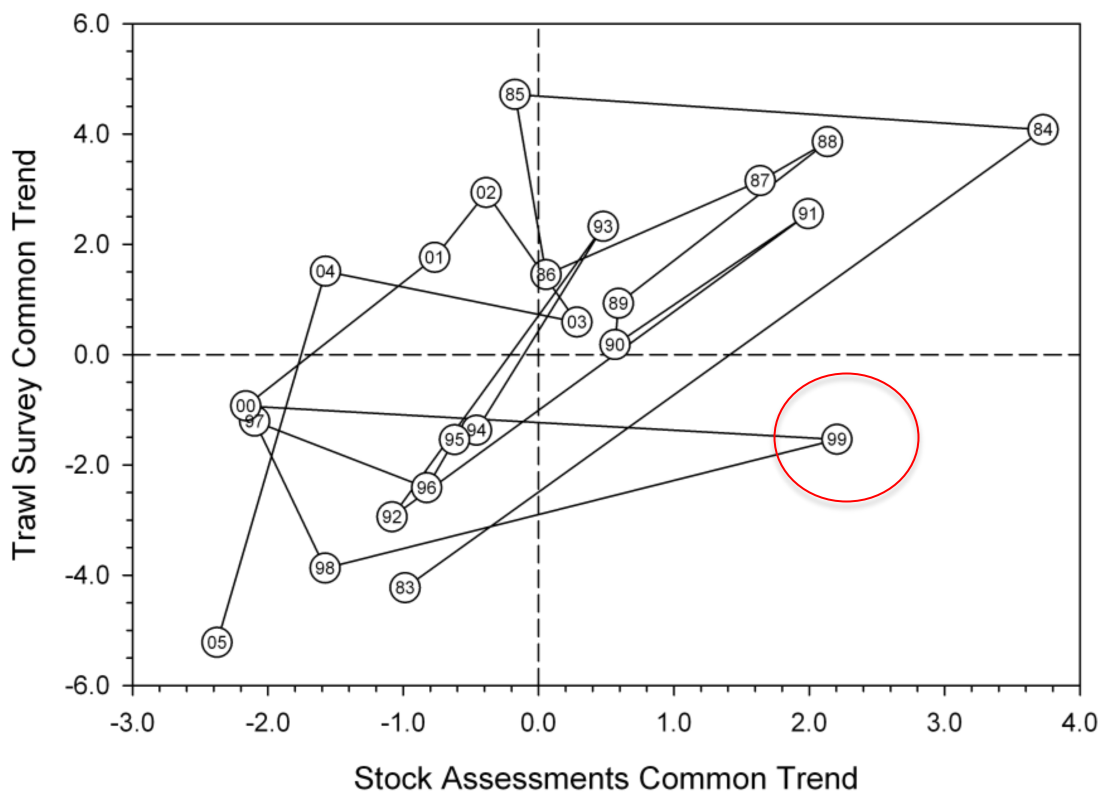


Survey has provided indices for stock assessments of eight species over time (bocaccio, widow, canary, chilipepper, black, blue, shortbelly and Pacific hake), in seven of the most recent. Prior to 1999, fits looked great…

Standardized anomalies from Delta-GLM year effects for the ten most abundant species in the core area (from Ralston et al. 2013)



NOAA FISHERIES



The first PC of juvenile indices from the core area compares well (R^2=0.39), with the first PC of a time series of recruitments for five of the assessed species for which good estimates are available.(bocaccio, chilipepper, widow, canary and shortbelly) (Ralston et al. 2013), albeit not quite well enough…

NOAA FISHERIES

2006 Pre-recruit workshop recommendations

- The spatial coverage from1983-2000 likely inadequate to index pre-recruit abundance for most species (barring oceanographic covariates)
- Comparison of methods and patterns in catch rates indicated that the SWFSC and PWCC/NWFSC surveys were could be pooled
- Indices developed with four methods: 1) core area; 2) design-based, (3) a delta-GLM, and 4) ANOVA . Panel recommended ANOVA
- As Regional Ocean Model Systems (ROMS) or other models improve, could help survey design and interpretation of results
- Surveys provide significant insights into ecosystem dynamics, micronekton species trends, indicators of environmental fluctuations

Coastwide data availability

Year	Latitude									Total
	32	34	36	38	40	42	44	46	48	
2001		6	70	58	22	19	19			194
2002		6	67	52	19	21	17			182
2003		8	73	71	21	22	19			214
2004	8	29	76	74	28	20	27	22		284
2005	13	28	92	62	35	17	22	21	12	302
2006	14	24	84	86	41	21	20	22	13	325
2007	11	17	79	86	38	25	22	22	16	316
2008	13	20	43	43	37	21	22	18	15	232
2009	7	19	59	79	30	24	23	23	16	280
2010	**6**	**15**	**44**	**52**	**16**					**133**
2011			**29**	**30**	**4**	*	*	*	*	**63***
2012	**3**	**13**	**51**	**27**						**94**

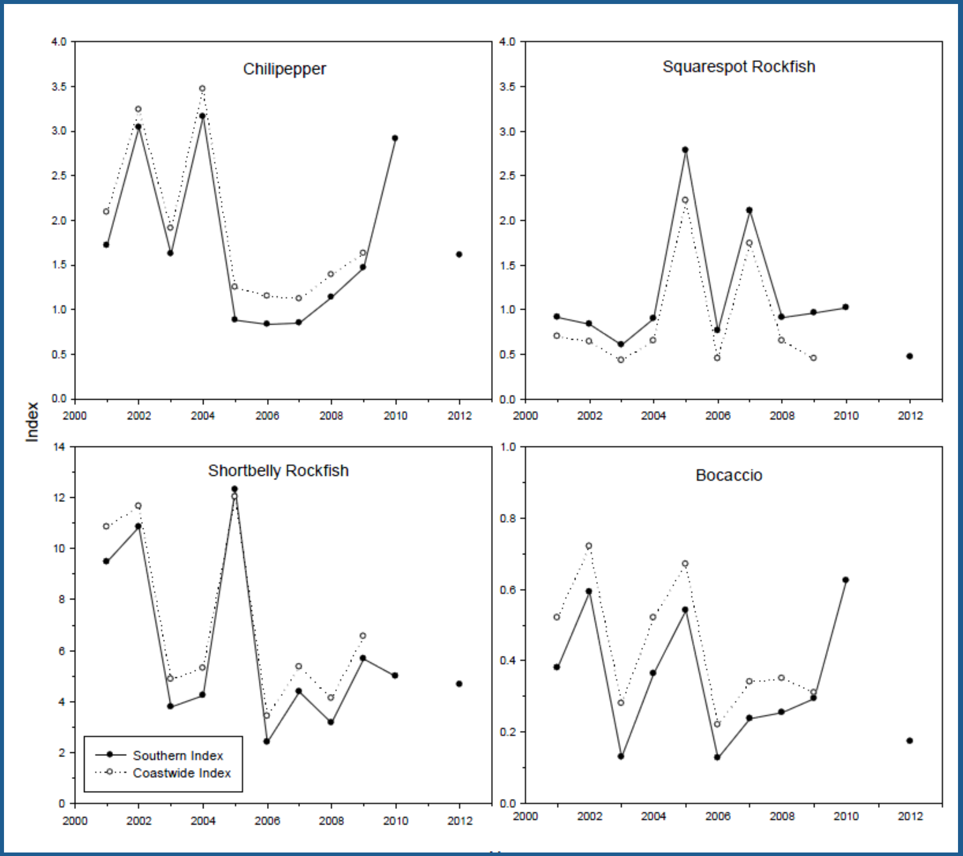
Report recommended revisiting performance after additional 5 years of comparable coastwide results; this year was 5th since report of (near) coastwide coverage, a more rigorous comparison is now feasible

Most Recent Indices

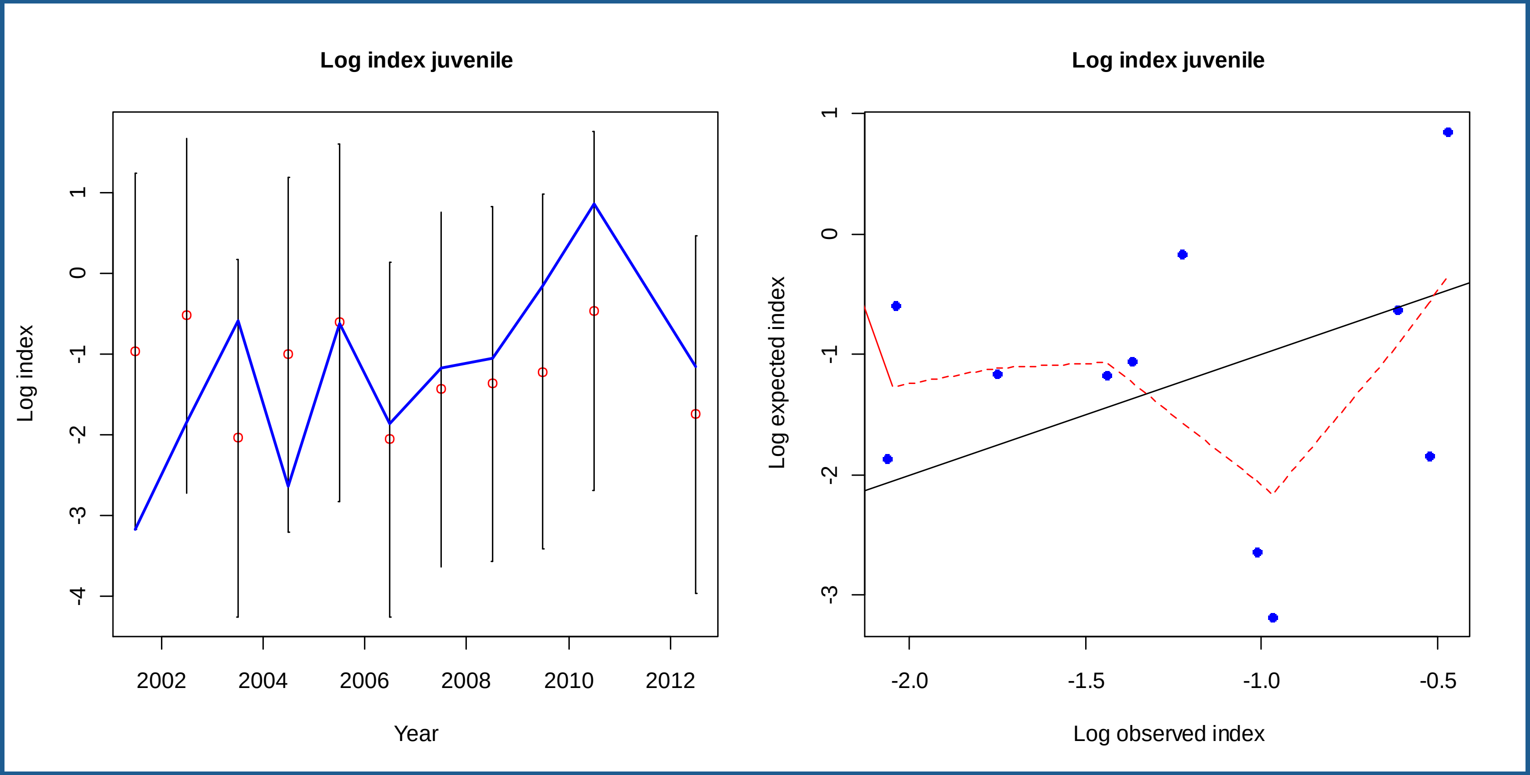
Indices development most recently has used ANOVA with random vessel effects (workshop rec); developed for most species in 2010.

Absence of northern data in recent years has constrained us to reporting solely on a few southern species in 2012 (but less need)

With 2013-14 data, we can develop coastwide indices for a number of species for 2015 assessment cycle



$$\log(N+1) = f(\text{year}\times\text{latitude, vessel, period, and depth})$$



Bocaccio juvenile index from coastwide data used in most recent (2013) update. Fit is considerably better from 2004 onward (when S. California Bight covered), next full assessment will drop pre-2004.

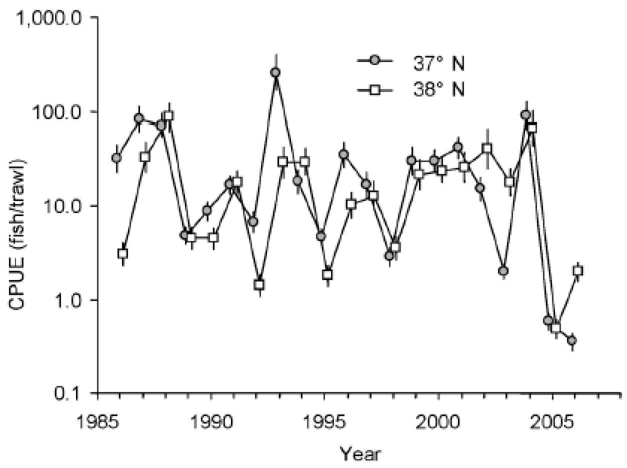
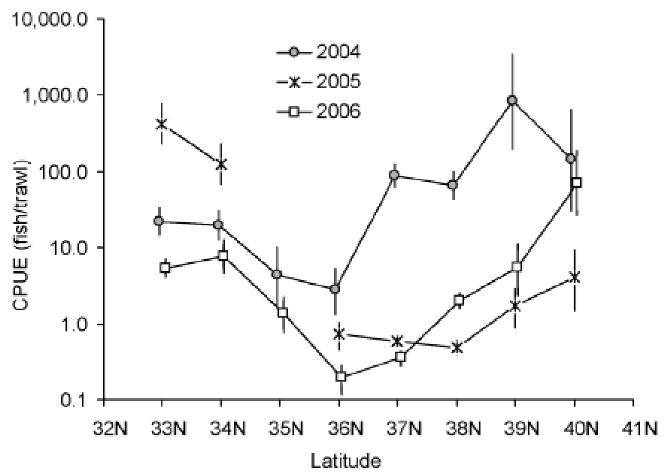


Figure 4. Average catch-per-unit-effort (CPUE; based on means of log_e [N + 1]) of YOY Pacific hake (*Merluccius productus*) by year in 1° latitude bins of NOAA Fisheries, SWFSC Juvenile Rockfish Survey core (central California) stations, 1986–2006 (± 1 standard error).



Phillips et al. 2007

Pacific hake (whiting)

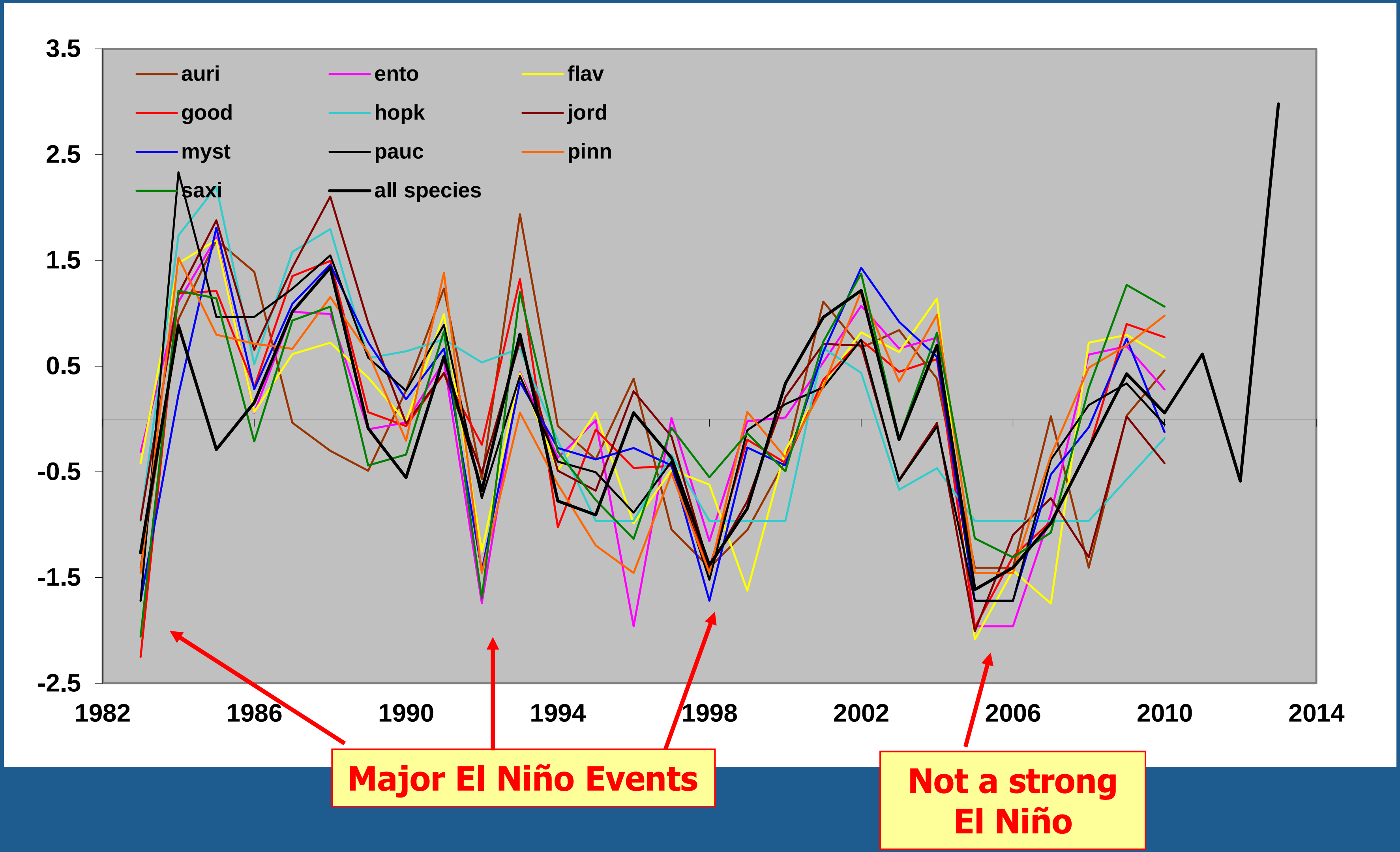
- Indices of year class strength have been developed in the past, but have missed key years (2004-2005).
- Mid-2000s analysis (NWC/SWC work) suggested a northward shift in distribution, but this may have been transient.
- With coastwide data and strong recent year classes, a hake index should be revisited

2013 is also looking like a tremendously strong recruitment year for winter spawners from several other indices as well (power plant impingement, PISCO and other diver surveys, anecdotal accounts).

Survey Objectives

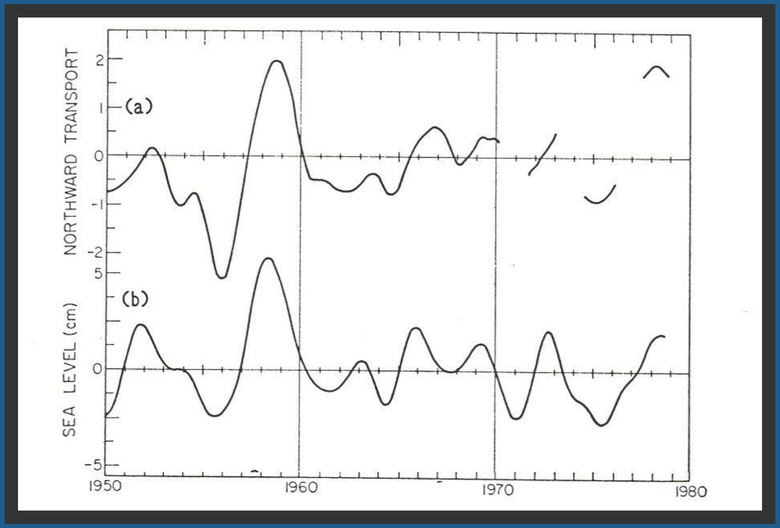
- Develop estimates of abundance for pelagic Young-of-the-year (YOY) rockfish (*Sebastes* spp.) and other groundfish (to the extent practicable) for use as pre-recruit indices in stock assessments (Assessment survey)
- Improve our understand of the physical and biological ecosystem factors that lead to strong or weak year classes (Process studies)
- To improve our understanding of the spatial and temporal variability in the micronekton (forage) assemblage, including the role of YOY rockfish and other groundfish within that assemblage, particularly as related to climate variability and oceanographic conditions (Ecosystem studies)

Standardized anomalies from Delta-GLM year effects for the ten most abundant species in the core area (from Ralston et al. 2013)

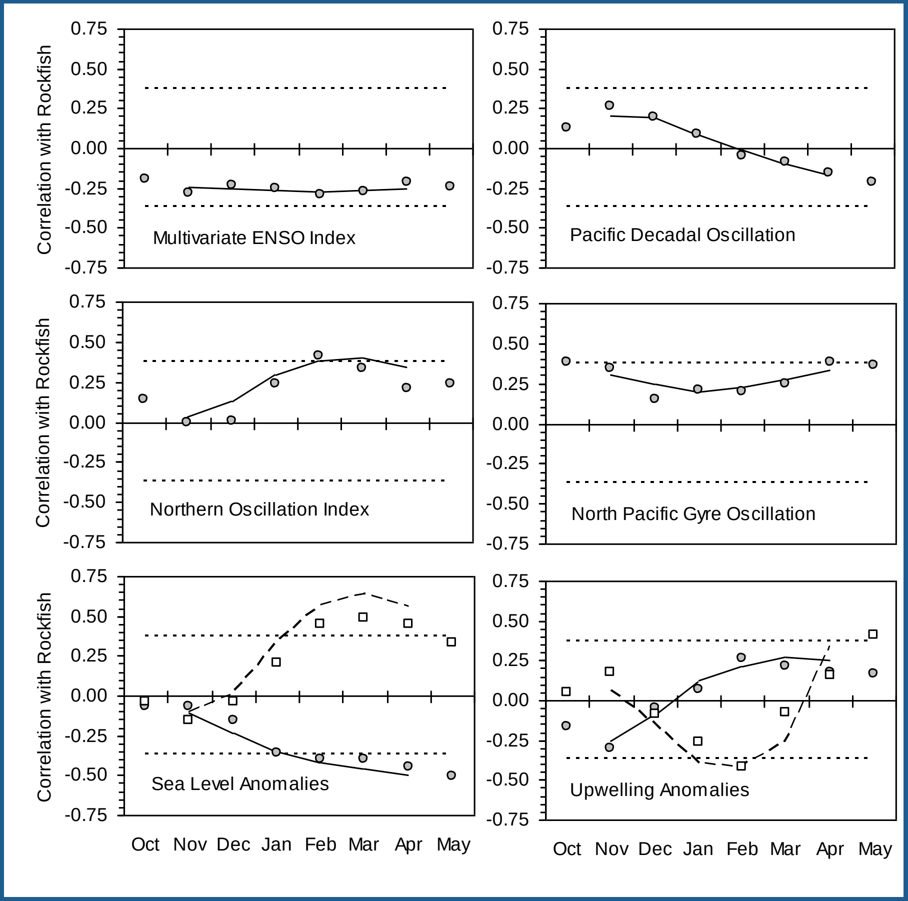


NOAA FISHERIES

Changes in sea level track geostrophic flow and productivity in the California Current, and had the strongest correlation of environmental variables to juvenile rockfish abundance



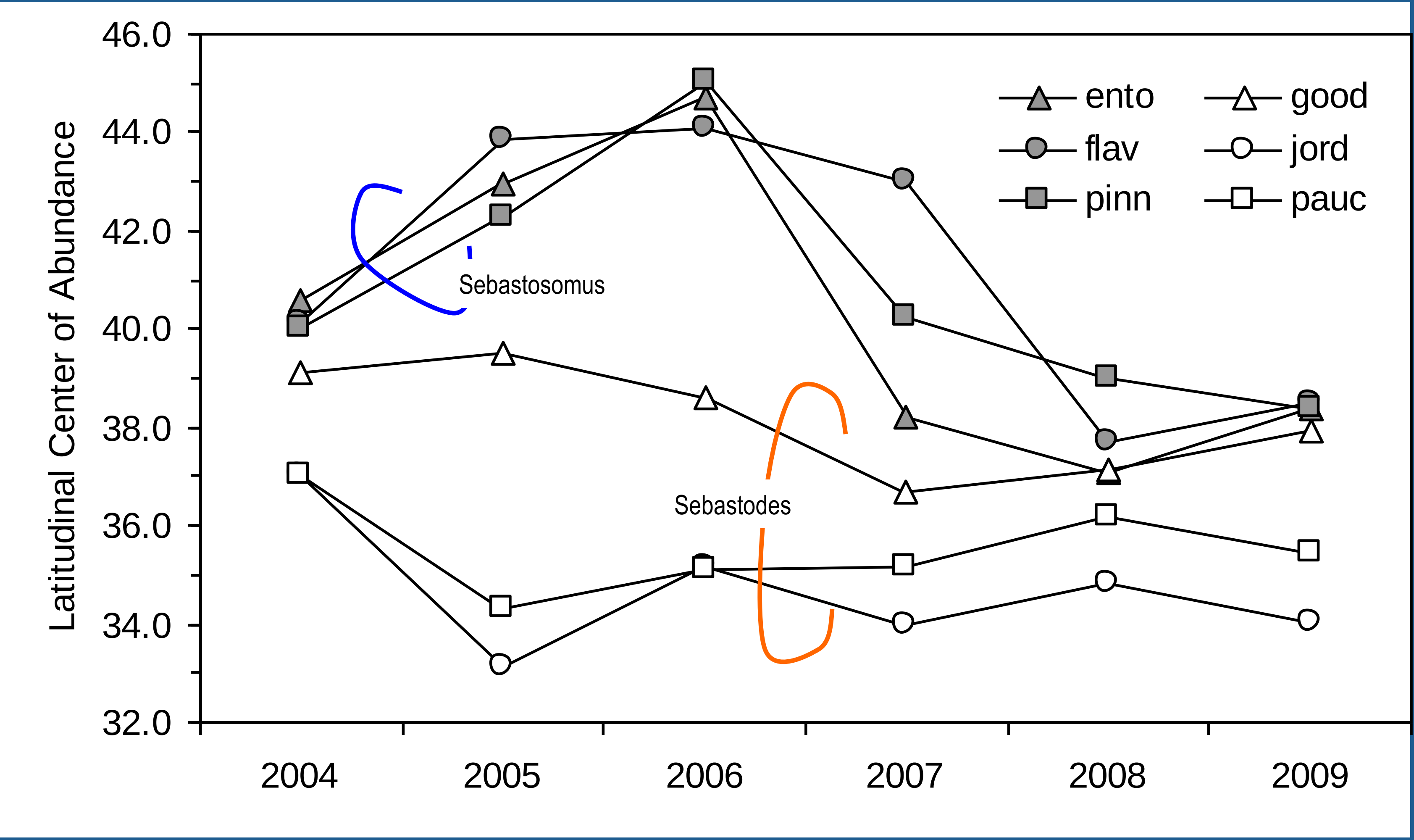
Chelton et al. 1982



Ralston et al. 2013

NOAA FISHERIES

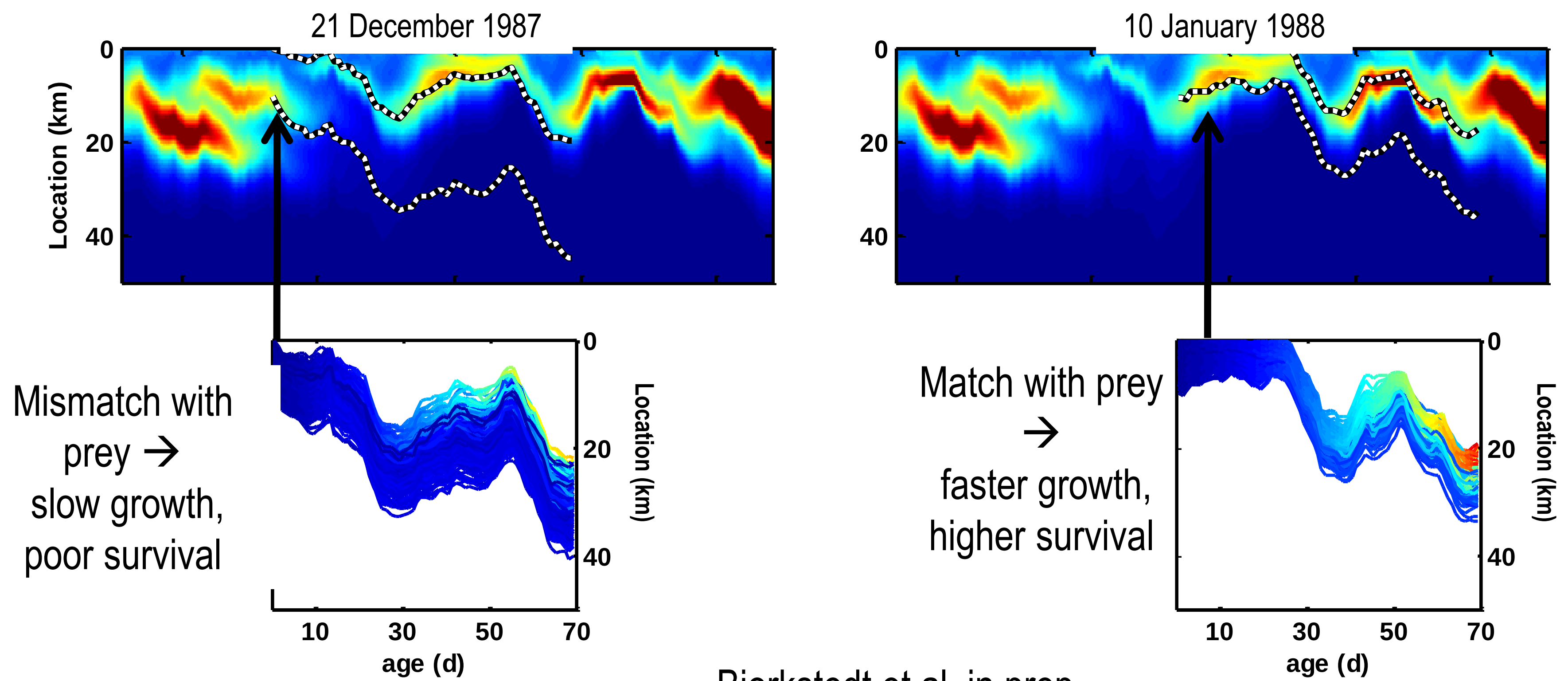
Bifurcated Spatial Distributions in 2005-2006



Ralston and Stewart 2013

Mechanistic models of rockfish recruitment

Simulate physical and ecosystem response of coastal upwelling system (2D ROMS model), integrate effects of environment and prey availability on larval survival using individual-based models.

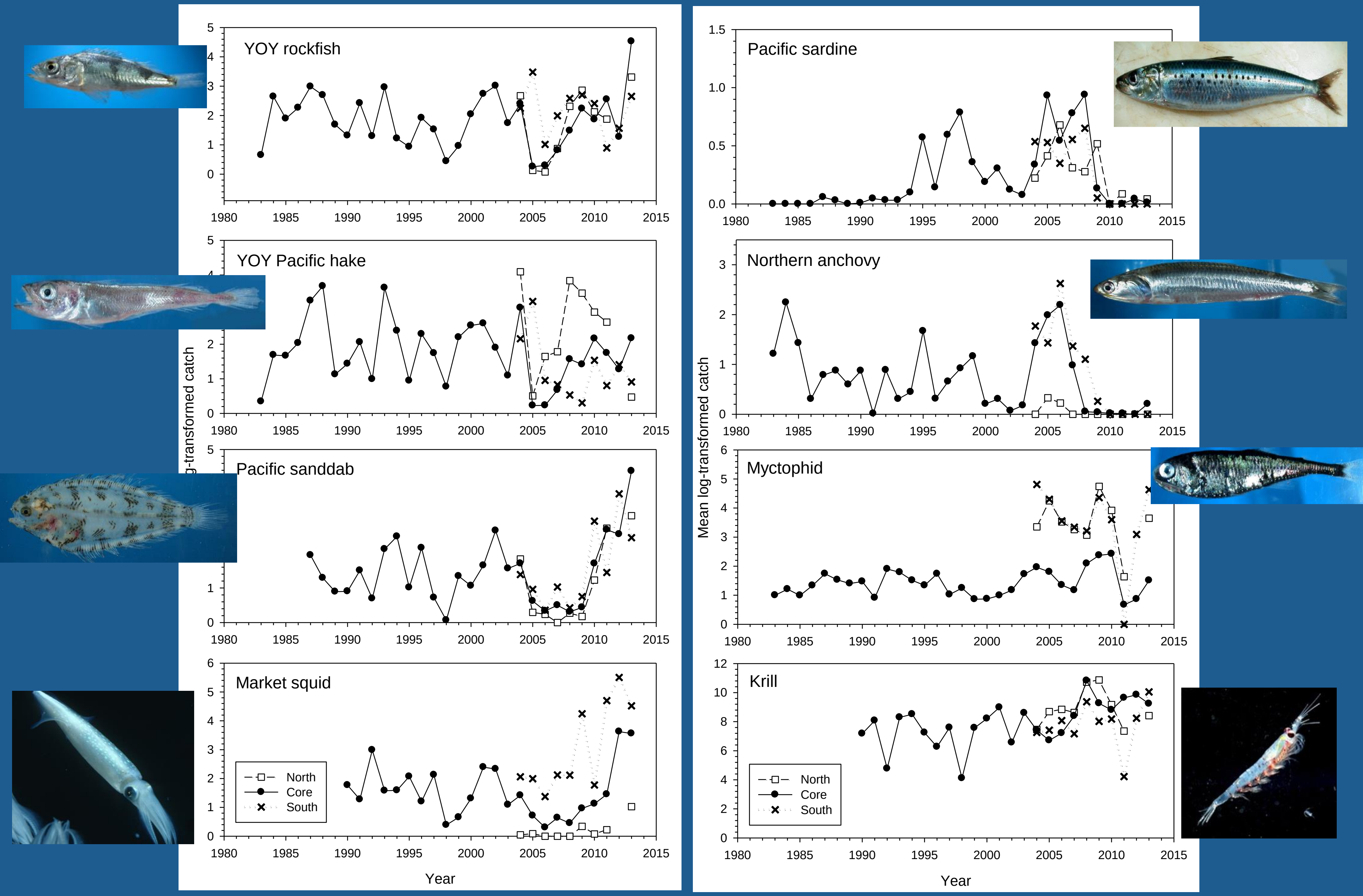


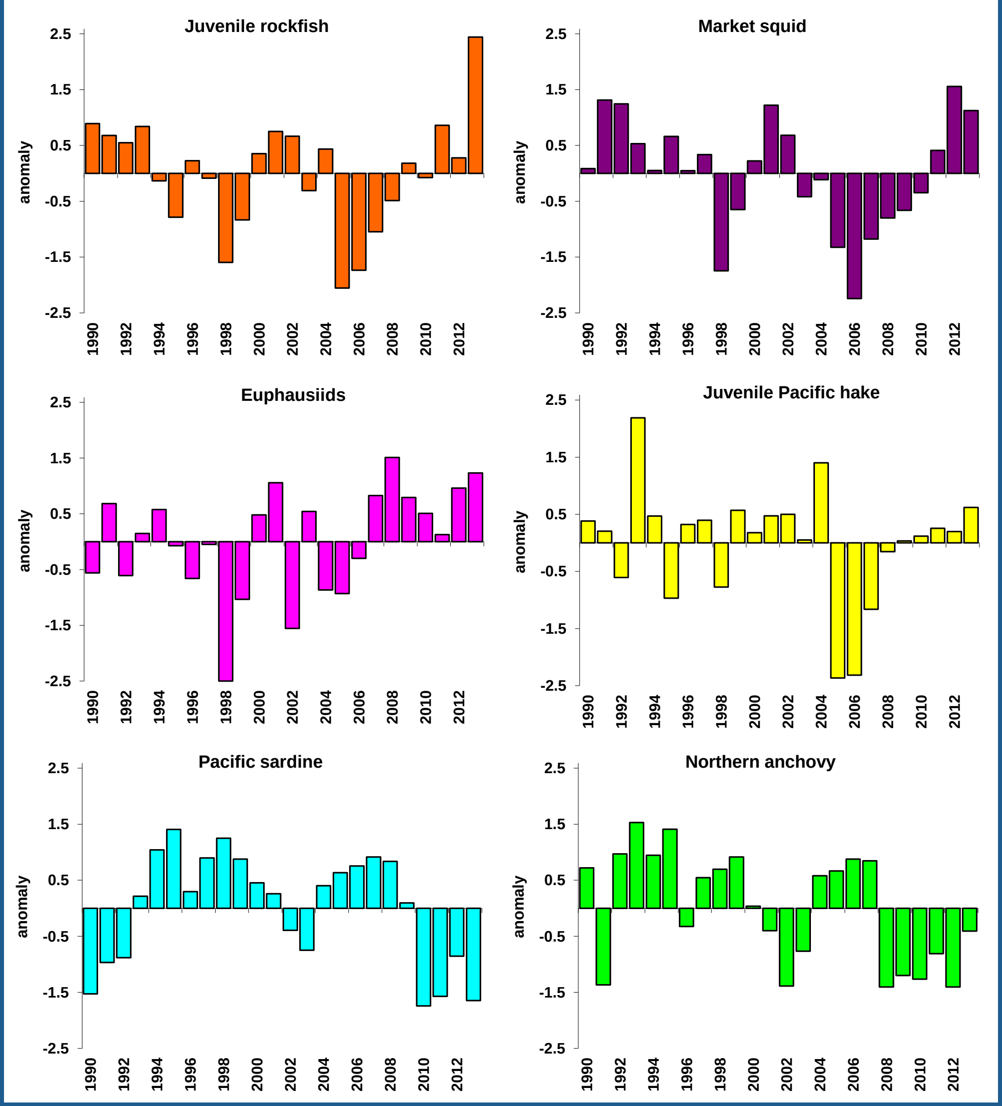
Bjorkstedt et al. in prep

NOAA FISHERIES

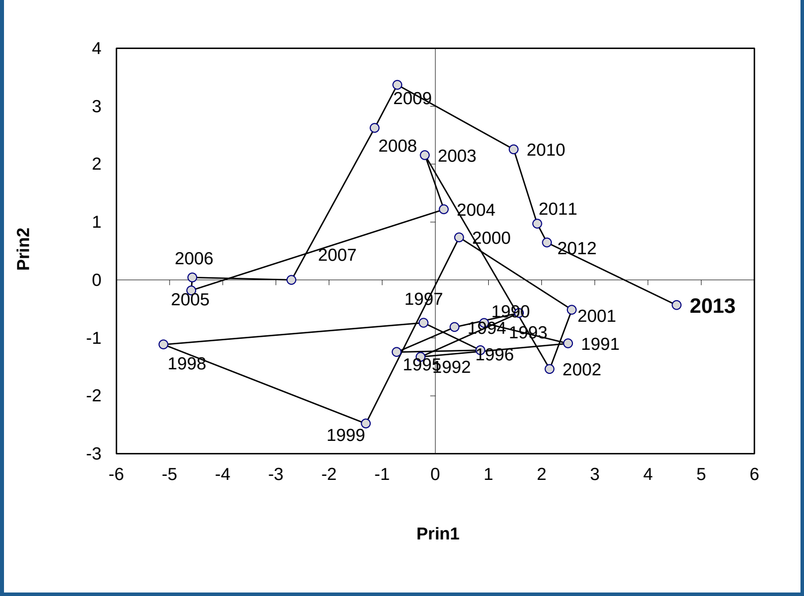
Survey Objectives

- Develop estimates of abundance for pelagic Young-of-the-year (YOY) rockfish (*Sebastes* spp.) and other groundfish (to the extent practicable) for use as pre-recruit indices in stock assessments (Assessment survey)
- Improve our understand of the physical and biological ecosystem factors that lead to strong or weak year classes (Process studies)
- To improve our understanding of the spatial and temporal variability in the micronekton (forage) assemblage, including the role of YOY rockfish and other groundfish within that assemblage, particularly as related to climate variability and oceanographic conditions (Ecosystem studies)


YOY rockfish
YOY Pacific hake
Pacific sanddab
Market squid
Pacific sardine
Northern anchovy
Myctophid
Krill
North
Core
South
Mean log-transformed catch
Year
1980
1985
1990
1995
2000
2005
2010
2015

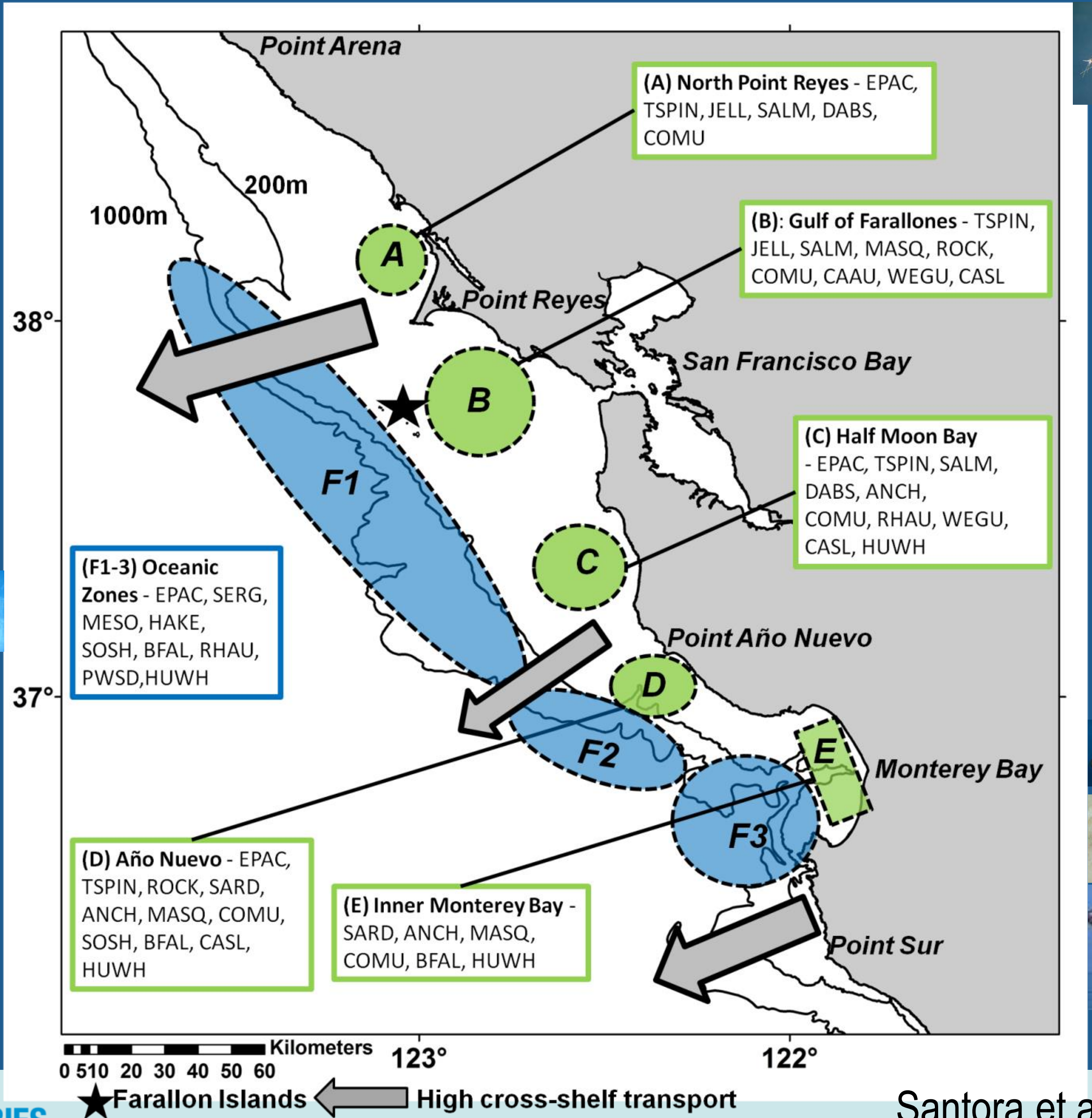


Juvenile groundfish covary in abundance with much of the other micronekton that provide the forage base for the California Current ecosystem- we have used PCA-based indices as indicators of ecosystem state



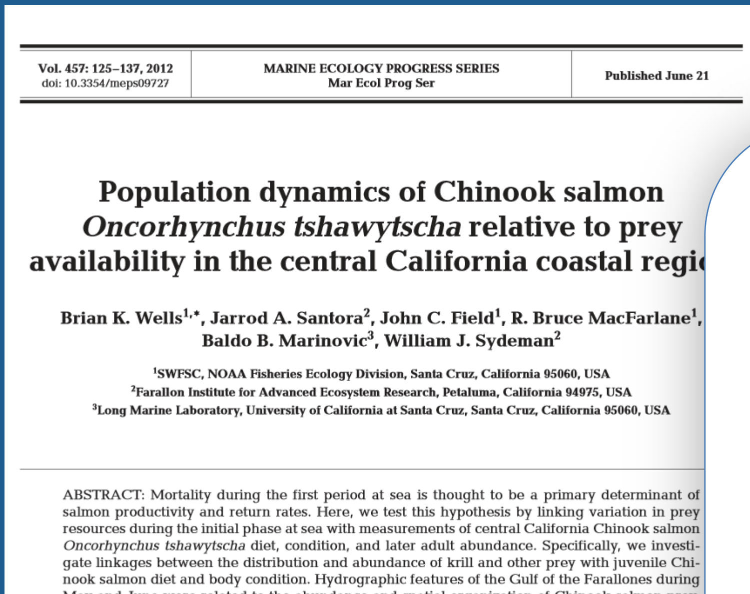
NOAA FISHERIES

Spatial analysis to evaluate community structure and "ecologically important areas"



Santora et al. 2012

NOAA FISHERIES



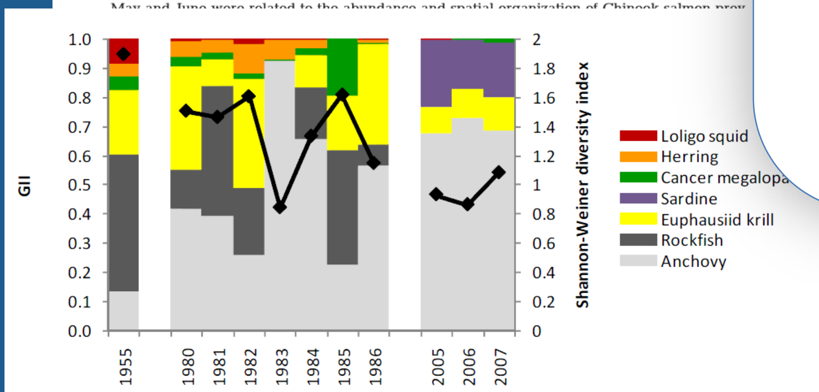
Vol. 457: 125–137, 2012
doi: 10.3354/meps09727
MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser
Published June 21

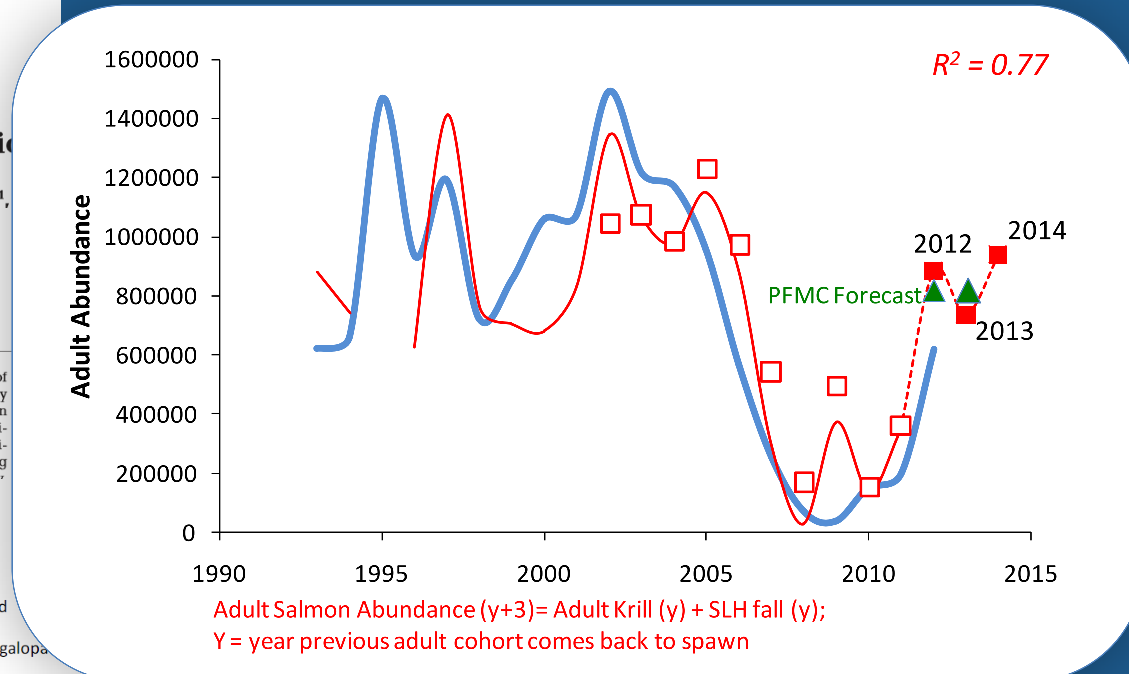
Population dynamics of Chinook salmon *Oncorhynchus tshawytscha* relative to prey availability in the central California coastal regi

Brian K. Wells[1,*], Jarrod A. Santora[2], John C. Field[1], R. Bruce MacFarlane[1], Baldo B. Marinovic[3], William J. Sydeman[2]

[1]SWFSC, NOAA Fisheries Ecology Division, Santa Cruz, California 95060, USA
[2]Farallon Institute for Advanced Ecosystem Research, Petaluma, California 94975, USA
[3]Long Marine Laboratory, University of California at Santa Cruz, Santa Cruz, California 95060, USA

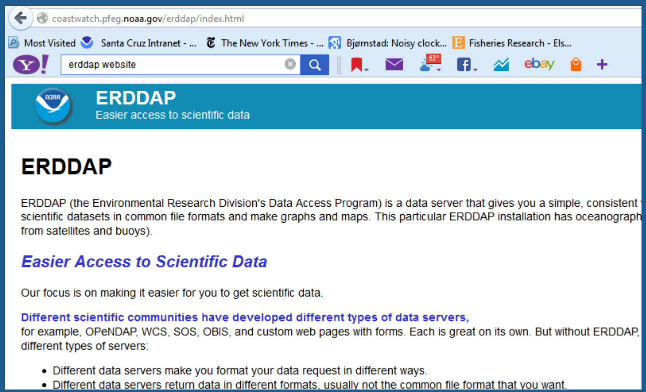
ABSTRACT: Mortality during the first period at sea is thought to be a primary determinant of salmon productivity and return rates. Here, we test this hypothesis by linking variation in prey resources during the initial phase at sea with measurements of central California Chinook salmon *Oncorhynchus tshawytscha* diet, condition, and later adult abundance. Specifically, we investigate linkages between the distribution and abundance of krill and other prey with juvenile Chinook salmon diet and body condition. Hydrographic features of the Gulf of the Farallones during





Micronekton community (particularly krill) appears to relate well to salmon survival and productivity, several large research efforts (NASA, OPC funded projects) have investigated this, some potential to inform salmon assessments

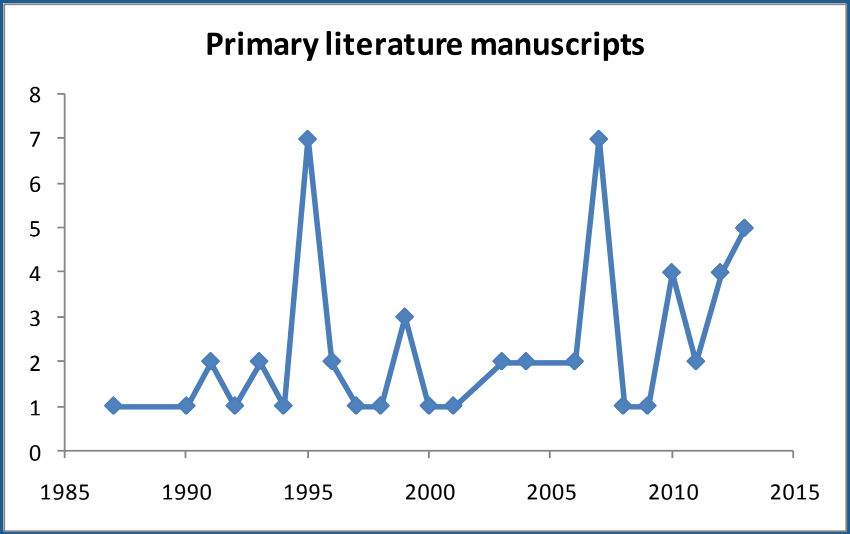
Collaborators and data sharing



Environmental data (CTD) served on Environmental Resources Division ERDDAP website, biological data served on SQL relational database in Santa Cruz (not currently available online). Since 2002, >150 data requests filled for biological data.

Since 2001, participants, collaborators or those requesting data outside of NOAA have included UC Santa Cruz, UC Berkeley, UC Santa Barbara, UC San Diego (SIO), Hopkins Marine Station Stanford, San Francisco State Romberg Center, Cal Poly, Moss Landing Marine Lab, U of Oregon, U of Washington, U Massachusetts, California Department of Fish and Game, Elkhorn Slough National Estuarine Research Reserve, Pacific Whiting Conservation Cooperative, Point Reyes Bird Observatory (new names), Farallon Institute for Advanced Ecosytem Studies, San Francisco Estuary Institute, Ocean Conservancy, Audobon Society, Japan National Fisheries Research Institute. At least 2 PhDs and 9 Masters thesis have relied heavily on cruise data

Impacts



- Provided indices for stock assessments of eight species over time, including most recent bocaccio, widow, canary, chilipepper, black, blue, shortbelly (in past, hake)
- Contributions to literature; at least 54 publications in peer reviewed literature, referenced at least 1250 times (google-scholar, excluding tech memos, cruise reports, etc)
- Provided information for numerous ecosystem status reports- CalCOFI State of the California Current Reports, PaCOOS Quarterly Reports, California Current IEA

Strengths

- Staffing- between 5 and 8 biologists on any given leg, but typically two to three FTEs; most staffing by non-FTE partners
- For some stocks, we see good relationship between indices and realized recruitment (bocaccio, widow)
- Indices of micronekton community structure relate well to ecosystem (seabird, salmon and other species) productivity, potential utility for other assessments (e.g., salmon), widely used in ecological community (bird, mammal people) and in status reports (CalCOFI SoCC, IEA, others)
- Time series among the longest on the West Coast, increasingly valueable for understanding impacts of climate variability and change on managed stocks as well as ecosystem structure

Challenges

- So far, most indices not very accurate, not highly influential in assessments. Validation of performance for other species is key to moving forward
- Ability to forecast other groundfish beyond rockfish (particularly Pacific hake) not yet been adequately demonstrated
- Understanding of physical ocean processes driving recruitment success mechanisms is improving, but factors driving mesoscale distribution still not well understood
- Cost of white ship time is substantial, much data is environmental or data related to ecosystem processes (indicators, IEA, ecosystem models)

Solutions

- Evaluate and/or simulate the performance of recruitment indices to assess their real and/or potential contribution to assessments
- Evaluate spatial and temporal covariance of coastwide catch rates to assess critical areas and time periods necessary to adequately monitor year class success
- Could potentially be accomplished on smaller vessels (e.g., charters), involves trade-offs in what data can be collected
- Understanding of physical ocean processes driving recruitment success is improving, long time series of oceanographic plus biological data can ultimately inform ROMS, IBMs, other models
- This year (2013) represents a huge opportunity to better understand processes driving high productivity/recruitment years coastwide